Evaluation Measurement & Verification (EM&V) of California Energy Star New Homes: Energy Savings Methodologies

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Presentation Highlights

- Purpose of evaluation
- Challenges of evaluation
- Prerequisites for effective impact evaluation
- General approach to evaluation
- Impact evaluation methodologies used, advantages and challenges (billing, metering, modeling)
- Select findings
- Conclusions

Overview of California 04-05 Energy Star Homes Evaluation Activities

Objective	On-site inspections	Billing Analysis	Metering Analysis	Modeling Analysis	Participant market actor surveys	Non-participant market actor surveys	RNC Baseline Study
Impact Evaluation	x	x	x	x	x	x	x
Process Evaluation	x				x	x	

- Market actors include builders, homeowners, utility staff, Home Energy Rater registry staff, and plan check consultants

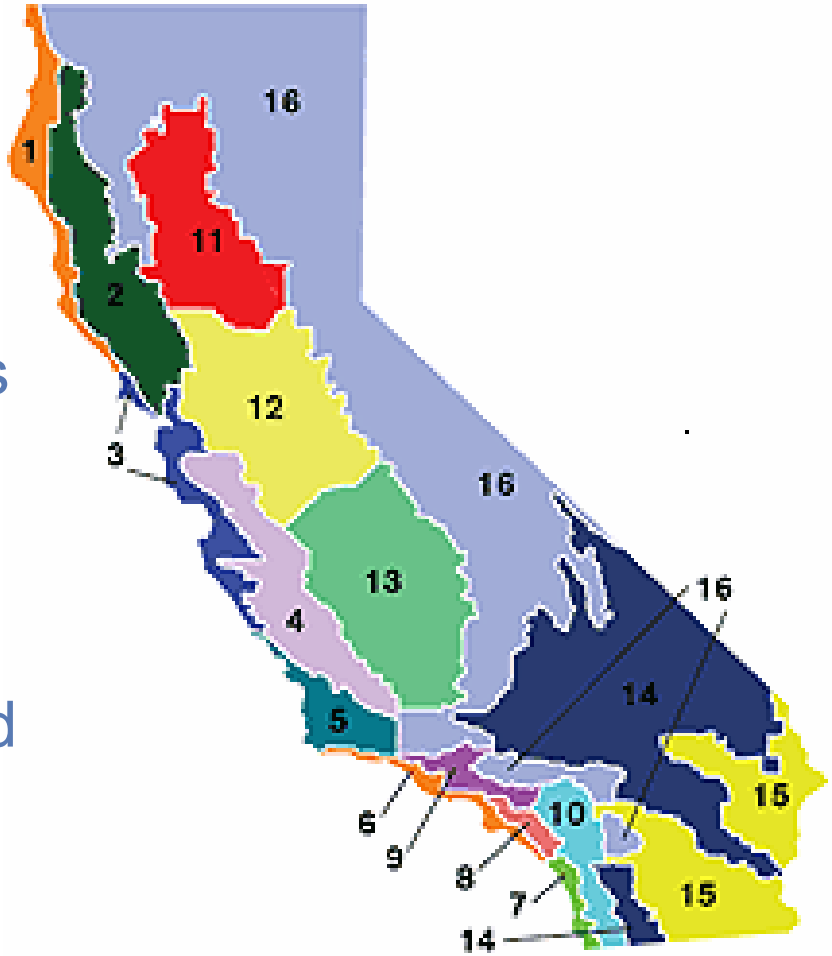
Background

- Statewide program PG&E, SCE, SDG&E, SCG
- 2004-05 evaluation performed by RLW Analytics, Inc.
- Energy Star Homes in CA means > 15% Title 24
- Evaluation background
  - CA Evaluation Framework (document)
  - CPUC defined and approved SOW, utilities managed evaluation
  - 04-05 Evaluation begun after program close in 2006
- Number homes/dwelling units

Utility	2004-05 Dwelling Units			
	Single Family	Multi-Family	High Rise	Total
PGE	12,309	2,758	269	15,336
SCE	13,297	2,791	504	16,592
SCG	1,191	6,322	602	8,115
SDGE	4,316	7,257	733	12,306
Total	31,113	19,128	2,108	52,349

California Energy Star Homes
Title 24 and 16 Climate Zones (CZ)

- Widely varying energy usage in each CZ
- Title 24 requirements vary by CZ
- Energy Star program requires HERS inspections
- Coastal = CZ 1-7
- Inland = CZ 8-16
- Single family units 86% inland
- Multi-family units 59% inland



Purpose & Goals of Evaluation

- To help ensure good decision making for energy program resources ($)
- Estimate specific program effects, for example:
  - Program cost effectiveness?
  - Are savings "real"?
  - What are gross and net savings (impact evaluation)? **(Focus of this presentation)**
  - And many others
- Attempt to understand how program effects occurred to make recommendations for increased program effectiveness
- To fulfill requirements

Fundamental Challenge of Impact Evaluation

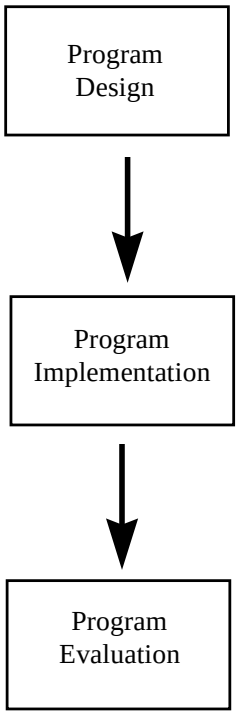
- Measuring energy use that *didn't happen*
- For Energy Star New Homes:
  - Estimating program effects of new Energy Star homes compared to non-participant homes
  - Determining appropriate participant classes for evaluation (e.g. by utility, climate zone, SF vs. MF, single story/multi-story, end-uses, energy types, others)
  - Estimating energy savings of even a <u>single home</u> is challenging!
- Evaluation is part science and part art

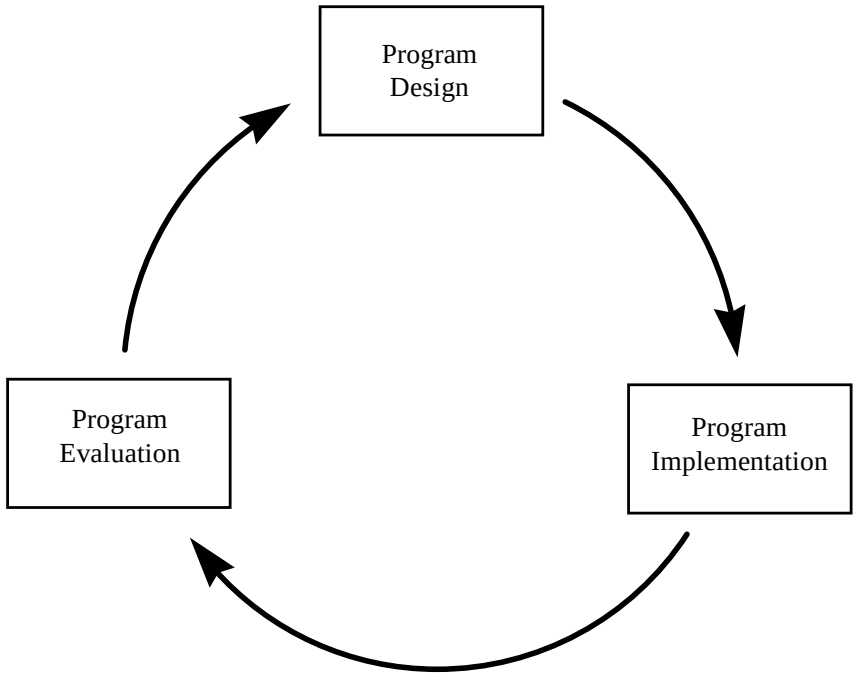
Program Timing

- Time to build-out projects typically (1-3 years)
- Participant accounting is critical
  - California program impacts are accrued when they are realized (built/installed, inspected, approved)
  - This can be years after the program application is completed for new construction
  - Building code changes can occur every few years
- Net result: ES homes evaluated in 2006 may be from program years ‘03, ‘04, ‘05, ‘06 and span more than one building code

Approach to Evaluation

- Sequential vs. Integrated Evaluation





- Evaluation results 2+ years after program cycle do not support timely decision making

Prerequisites for Effective Evaluation

- A well-conceived program theory and logic model
- Complete and accurate program tracking data

California Energy Star Homes ’04-’05 Evaluation Activities

- Billing Analysis
- Metering Analysis
- Modeling Analysis

Billing Analysis

- Approach and advantages
  - Examine the billed energy use of the participants and non-participants
  - Uses existing metered consumption data
  - Possible to have very large sample sizes (both P and NP)
- Challenges
  - Data acquisition - Multiple fuel types provided by multiple sources
  - Data management
  - De-aggregating billing data (example: cooling)
  - Large variability of household usage (variance can swamp differences)
  - Controlling for differences in participants vs. non-participants (e.g. floor area, occupancy, income, stories)
  - Behavior – how do participant intentions and behavior affect energy savings? E.g., snap-back, energy efficiency attitudes, etc.
- Responses
  - Use regression analysis to statistically control for other factors affecting energy consumption
  - Carefully select large samples of participants and non-participants
  - Careful data QA/QC

End-use Metering Analysis

- Approach and advantages
  - Directly meter energy usage on specific end-uses of interest (space heating, cooling, and water heating)
  - Focuses on the affected measures and end-uses to reduce variation and bias from other factors
  - Examine the installed measures in a sample of the participants and use the engineering model and site-specific data to the savings at each site.
- Challenges
  - Data acquisition – Cost, time, losses, access to homes
  - Variance of usage still very large
  - Sample size(s) – how many participants (and NP's) for meaningful results?
  - Sample bias – are the samples representative?
  - Measurement plan – what are the key factors affecting use or savings? Behavior – how do participant intentions and behavior affect energy savings? E.g., snap-back, energy efficiency attitudes, etc.

Modeling Analysis

- Approach and Advantages
  - Use energy modeling to simulate usage and savings
  - Takes advantage of models created for code compliance
  - Can be performed on entire population of participants
  - Can compare
- Challenges
  - Compliance software (models) not intended to estimate energy consumption
  - Data acquisition -- Requires obtaining/modeling representative non-participant homes (Requires a baseline study)
  - Trickier for multifamily housing
  - Homes often not built exactly as modeled
  - Program compliance is also through modeling, so not an independent verification

Select Results (1)

- Billing, metering, and modeling methodologies showed some conflicting results
- Metering analysis showed less overall energy usage than models predicted
- Billing analysis sometimes showed greater energy usage in Energy Star homes
- Metering and billing analyses showed large variance in usage (as expected)

Select Results (2)

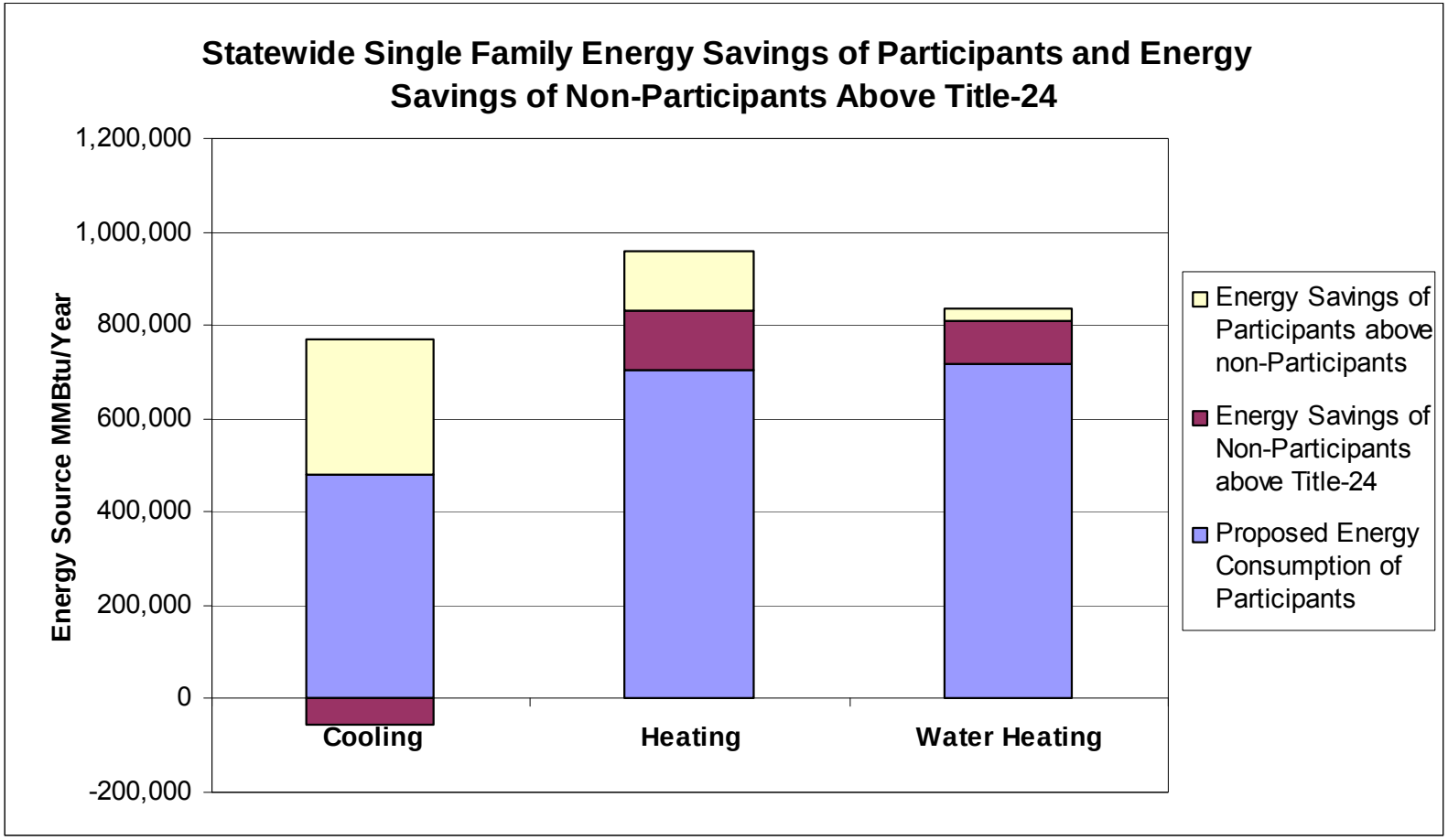
- Orientation of homes can have a significant impact on modeled energy savings
- Production homes usually modeled N, E, S, W

Climate Region	End Use	Single Family B-Ratios for Orientation Adjustments	MultiFamily B-Ratios for Orientation Adjustments
Coastal	Cooling	1.46	1.35
	Heating	1.24	1.14
	Water Heating	1.00	1.00
Inland	Cooling	1.25	1.27
	Heating	1.17	1.07
	Water Heating	1.00	1.00

Ratios of energy savings from average orientation to worst orientation

- Example: Inland cooling modeled energy savings averaged over N, E, S, W is 25% greater than the worst orientation's energy savings

Select Results (3): Single Family Free Ridership Varies by End Use



Total height of bar represents Title 24 Standard design energy use

Conclusions

- Integrated approach to evaluation preferred over sequential
- Single family impact analysis is complex, multifamily even harder
- Critical for program (and evaluation) to define “savings” as inclusive or exclusive of occupant behavior (take-back)
- Large variance in individual energy usage challenging particularly for metering methodologies
- Evaluators must carefully consider participant classes for evaluation (results may vary by end-use, fuel type, other classes)
- Modeling software appears to be a poor predictor of consumption, but may be good at estimating average savings
- Home orientation can have a significant impact on energy savings – large opportunity for savings in simple passive solar design
- The cost of engineering approaches depends on the accuracy of the tracking estimates of savings
- Final report available at www.calmac.org in May